PHILOSOPHICAL

TRANSACTIONS.

I. *An Account of the circulation of the blood in the class Vermes of Linnæus, and the principle explained in which it differs from that in the higher classes.* *By Sir* Everard Home, *Bart. V. P. R. S.*

Read November 7, 1816.

HAVING spent a part of last August on the Sussex coast, where the Lumbricus marinus is met with in great numbers, it suggested itself as an object worthy of investigation, to determine the difference in structure between this worm and the Teredo on the one hand, and the Lumbricus terrestris on the other. I was the more led to this from having made myself familiar with the structure of the Teredo, an account of which has a place in the Philosophical Transactions.

These three different genera of worms, although they differ in many respects from each other, have several points of resemblance; they all destroy by boring the substances they inhabit, an action requiring great muscular power; they take into their stomachs the broken down substance; they have gizzards, and red blood; their place of residence however, being very different, requires that there should be peculiarities in

each of them, one of these is, the mode in which the blood is aerated.

We are not in my opinion furnished with a sufficient stock of materials in comparative anatomy, to make out a correct arrangement of the whole system of nature, nor do I know the best plan upon which it can be made; but, at present, I look upon the circulation of the blood, and the mode of aerating it, as one liable to the fewest objections.

The brain and nerves, as they are the most essential organs in the animal œconomy, appear to have a prior claim, but the difference of structure in those organs, and in the spinal marrow, is too small to serve for this purpose.

The heart and blood vessels are the parts next in importance, and necessarily vary more in their structure, so as readily to give characters to a greater number of classes, which is a great advantage. I have made these remarks from a desire that the science to which I have devoted much of my attention, should be pursued by those who engage in it, in the manner most likely to bring it to perfection, which is by submitting to the drudgery of making out the structures of animals not yet known, instead of grasping at the whole system, so many parts of which we are unacquainted with. This attempt resembles that of the giants of old, in the allegory, who foolishly believed, when they got hold of the lower links of the golden chain which hung down from heaven, that they had acquired the means of getting possession of the power by which it was suspended.

The circulation of the blood in the Lumbricus marinus, is probably the same as in all the vermes with external organs of aeration. The transparency of the animal shows the action

of many of the blood vessels, and the course of the blood, but in some parts they are hid from our view, and are only to be detected by sudden coagulation of that fluid, which is effected by immersion in vinegar. I most readily confess, that had not Mr. CLIFT, the Conservator of the Museum of the Royal College of Surgeons in London, made sketches of the parts while in action, and given me his assistance, I probably should have failed in the investigation. The blood is brought from every part of the body to a common trunk that supplies the organs of aeration, which are 26 in number, but does not all pass through them, a portion of unaerated blood going on towards the tail.

The blood is propelled from the blood vessels of the organs of aeration with great force, these vessels performing the function of the ventricle of the heart in other animals; it is carried to a large artery on the back in an aerated state, passes towards the head, from thence it is returned by a corresponding vein on the belly, and before it arrives again at the organs of aeration, this vein receives supplies from two auricles furnished by the veins of the viscera; but there is no ventricle between the auricles and these organs.

In the Lumbricus terrestris there is no heart, and the organs of aeration are not external, but consist of small lateral cells with an external opening, as in the leech, so that they can take no part in propelling the blood; that office is entirely performed by the muscular power of the coats of the arteries. In this animal the circulation is very simple; the artery upon the back, by its action, forces the blood up to the head, and it is returned by a corresponding vein upon the belly; near the head there are five pair of lateral canals of commu-

nication between the artery and vein, which being kept full, furnish a supply of blood to be used when necessary, and admit of a greater or less proportion going to the head, or being returned by them to the vein, as occasion may require, their coats being exceedingly elastic.

From these observations on the circulation in the Lumbricus marinus, and Lumbricus terrestris, and those formerly made on that of the Teredo navalis, these genera appear to form three links in the chain of gradation of animals, and have led me to the belief, that the striking difference between the circulation of the blood in all the vermes, and that of the higher classes of animals, may be explained, and shown to answer an essential purpose in their œconomy.

In explaining my opinion, I shall make myself better understood, by reviewing in a summary manner the modes by which the circulation is carried on in the different classes of animals; this will also enable me to show that a classification of animals will at least be as perfect by taking the circulation of the blood for our guide, as the brain and spinal marrow.

In all animals of the class Mammalia, there is a complete double circulation; in the one, the blood is aerated; in the other, the body is supplied; they correspond in velocity, the aeration is great, the heat of the animal is kept up to a certain degree, and, if the action of the heart both in the auricles and ventricles has once entirely ceased, it cannot be restored. In birds, the circulation is completely double, but the aeration of the blood is less than in the mammalia, the lungs being smaller, and their cells larger; when the action of the heart has entirely ceased, it cannot be restored.

In the Amphibia the circulation is double, in appearance, but partially so in reality, the septum between the ventricles having apertures communicating from the one to the other; this structure renders the mass of blood less aerated, and the circulation less dependent upon the organs of aeration. Under these circumstances, the blood varies in its temperature with the atmosphere, and life is carried on under very imperfect degrees of aeration of the blood; but, when the action of the heart has entirely ceased, although the individual muscles of which it is composed can be irritated to produce contractions, for days, and weeks, yet the complete action of the whole organ cannot be restored.

In fishes the circulation of the blood is not double, as in the higher classes. The heart is composed of an auricle and a ventricle; the one is employed to receive the blood that has been used for the support of the body, and the other for propelling it through the organs of aeration; the aerated blood is collected into one artery, and passes to the different parts of the body for their nourishment, with no other impulse than what can be produced by the muscularity of the coats of the arterial system. It is true that the red blood does not go far towards the extreme parts. Even in this class, the circulation cannot be restored after the heart has been entirely at rest. Stories are told respecting fishes sold at market in North America in a frozen state, which, after they were carried home and gradually thawed, have been seen to move: to this I can very readily subscribe, since I have seen parts of quadrupeds completely frozen so as to be made solid, then thaw and recover. I have seen blood converted into ice in its blood vessel, thaw and become fluid, yet afterwards coagulate. I have also seen a carp after the heart and viscera were removed,

at the distance of many hours, when exposed to heat, leap to a considerable distance; but, when once the circulation has ceased, there is no authentic account of the circulation being restored. The lampreys have a less degree of aeration of the blood than fishes, and in that respect become an intermediate link between them and vermes; they have less the habits of muscular exertion, which may explain their having a less degree of aeration of the blood.

The vermes of LINNÆUS is a class made up of materials, which, in the present view of the subject, must be divided into five distinct orders. Those animals in which there is a heart; those in which there is no heart, but external organs of aeration; those in which the circulation is carried on by the arteries and veins of the body, there being neither heart nor external organs of aeration; those in which the blood does not circulate, but in which an undulation is kept up, a circulation for the purpose of aerating the blood being rendered unnecessary, as the aerating organs consist of air tubes that ramify through every part of the body, and those in which neither circulation nor undulation can be demonstrated.

In all the classes of animals above the Vermes, the heart is employed to receive unaerated blood, and to propel that blood into the organs of aeration; and in fishes, this is the only office it performs; but, in the class Vermes, the circulation is completely reversed, as I have formerly explained in the teredines, since the aerated blood goes to the heart, which propels it to the different parts of the body.

In so small an animal as the Teredo navalis, all the peculiarities of this kind of circulation were not readily made out, but by examining it in the sepia officinalis of a large size, I find that there is the same change in the office of the blood vessels

of the organs of aeration, as of the heart itself, since the vessels that carry the blood to these organs are larger and weaker than those which return it to the heart, so that, instead of the blood being propelled into the organs of aeration by arteries, it is carried by veins, and propelled towards the heart by arteries.

In proof of the correctness of my description of this kind of circulation, which I consider to be common to all that order, I have annexed two drawings of the heart of the sepia officinalis; they were made in the year 1787, by Mr. BELL, draughtsman to Mr. HUNTER, and the preparations from which they were taken are preserved in the Museum, and it is with the permission of the Board of Curators that the present copies are laid before the Society.

In the sepia, whose veins are of an enormous size, there is a bulb or swelling of the vein at the root of each of the organs of aeration, with a double valve to prevent regurgitation of the blood after it had once entered these organs; to this is connected a spongy body, that does not appear to communicate with the bulb itself, the use of which I am unacquainted with. This peculiarity appears to be wanting in the teredines and other vermes, as not being required.

The circulation of the blood in the lowest class of animals being the reverse in principle, to what it is in the higher classes, led me to consider, from what circumstances this change could be produced: and reflecting that the great difference, between animals of the higher classes and those of the vermes, is, that when the heart stops in the one, the animal dies, but in the other, that this action can be restored, it led me to believe, that the peculiarities in their circulation produce the means by which the action of the heart is renewed. Whether all the vermes upon any occasion go into a torpid

state, in which the circulation ceases, or what portion of them is in the habit of doing so, is no part of the present consideration; that some of them do, is sufficiently well ascertained, and the mode of their reanimation appears to arise from the air confined in the organs of aeration escaping, and fresh air being received, the effect of which, probably, is to excite the arteries of those organs to action, and consequently to send a supply of aerated blood to the heart. When the garden snail is shut up in the winter, all external communication is excluded, and therefore for months the action of the heart and of the organs of aeration must have ceased; when warmth and moisture are applied, the membranous films fall off, a globule of air that had been inclosed in the organs of aeration becomes rarified, it expands and forces its way out, and thus admits fresh air to be applied to the arteries of these organs.

In the second order of vermes, the external organs of aeration must cease to act, whenever the body of the animal is inclosed in sand, and will have their action restored as soon as fresh sea water is applied to them.

In the third order, in which the circulation consists only of arteries and veins, they also probably cease to act whenever the organs of aeration are not supplied, and renew their action whenever fresh supplies are received.

In the fourth order, the action of the blood vessels is scarcely necessary for the functions of life, the air vessels carrying the air to the blood, and retaining a considerable supply.

In the fifth order, the aeration of every part of the substance of the animal appears to be a substitute for any particular fluid having a regular circulation.

EXPLANATION OF THE PLATES.

PLATE I.

Exhibits a posterior view of the heart, aerating organs, and great veins in the Sepia officinalis.

AA. The vena cava anterior.

BBB. The venæ cavæ inferiores.

C. The vena cava media.

DDDD. Large canals officiating as veins, by receiving the blood from the different venæ cavæ; they have appendages of a peculiar kind like small grapes, which are hollow, and communicate by large orifices with their cavity. These are additional reservoirs, but they also secrete something that has a yellow tint.

EE. Two large venal trunks going to the organs of aeration.

FF. Two bulbs, in each of which is a pair of valves to prevent regurgitation of the blood from the aerating organs.

GG. Two small hollow spongy bodies which appear to have no direct communication with the bulbs to which they are attached.

H. The great vessel, which from its size I call a vein, going to supply the aerating organs.

I. The corresponding vessel, which from its size I call an artery, by which the blood goes from the aerating organs to the heart.

KK. The two auricles of the heart.

L. The ventricle.

M. The aorta.

NN. The inferior aorta.

OO. The aerating organs.

PLATE II.

The same parts shown in an opposite point of view.

AA. The vena cava anterior.

BBB. The venæ cavæ inferiores.

DDDD. The large veins with their appendages described in Pl. I.

EE. The ligamentous attachments, hiding the origin of the large vein that goes to the organs of aeration.

FF. The bulbs belonging to the veins that go to the aerating organs.

GG. The spongy bodies attached to the bulbs.

II. The arteries that return the blood to the heart.

KK. The two auricles of the heart.

L. The ventricle.

NN. The inferior aorta.

OO. The aerating organs.

PLATE III.

This plate exhibits three figures of the Lumbricus marinus, and one of the terrestris.

Fig. 1. The Lumbricus marinus as it appears when in full vigour, playing about in salt water. The mouth has the lips turned out, as if in search of food.

Fig. 2. The body of the animal is laid open, giving a view of the blood vessels which lie upon the back under the skin, and supported by the stomach and intestine on which they rest.

aaa. The great artery running from the tail to the head.

bbb. The nerve which lies upon it.

cccc. The external organs of aeration.

dddd. The blood vessels which I call arteries, that bring the blood from the aerating organs to the artery; under these are seen the veins which convey the blood to these organs.

eeee. Five very vascular bodies, probably answering the purpose of a liver.

f. The œsophagus.

g. The stomach.

hh. Two bags that communicate by small apertures with the stomach.

ii. The intestine laid bare, but not opened into.

kk. The two auricles lying upon the intestine just where it begins to swell out, one on each side.

ll. The two lateral veins that supply the auricles.

mm. Ova distinctly ascertained to be such.

Fig. 3. The skin longitudinally divided on the belly of the animal, and turned back so as to expose the parts immediately under it.

aaa. The vein corresponding to the artery on the opposite side.

bb. The termination of the two auricles in this vein, by infundibular vessels.

cccc. The vessels or venal branches going to the organs of aeration.

eeee. f, g, hh, ii, mm, the same as in the last figure.

Fig. 4. A representation of the arteries in the Lumbricus terrestris.

The animal is laid open by a longitudinal incision through

the skin of the back, which is turned aside, exposing the stomach and intestine upon which the artery lies.

aaa. The artery in which the blood has its course towards the head.

bbb. The five lateral canals, by which it communicates with the vein on the belly. These are inclosed as it were in separate cells.

cc. Œsophagus.

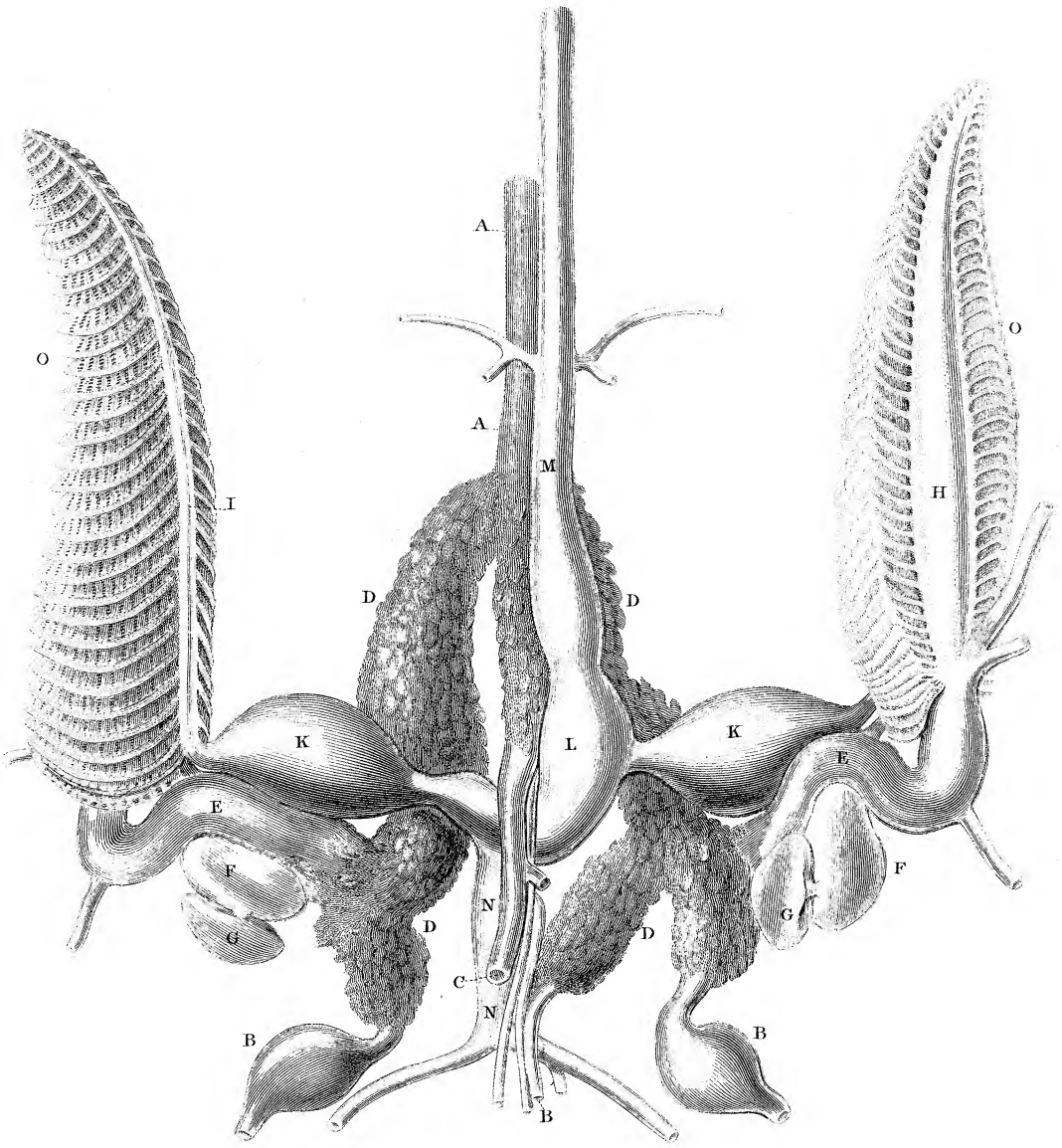
d. Crop.

e. Gizzard.

fff. The intestine made to put on a loculated appearance by transverse bands, which fix it in its situation.

gg. Ova.

hhhh. The organs of aeration, consisting of cells, with openings through the external skin.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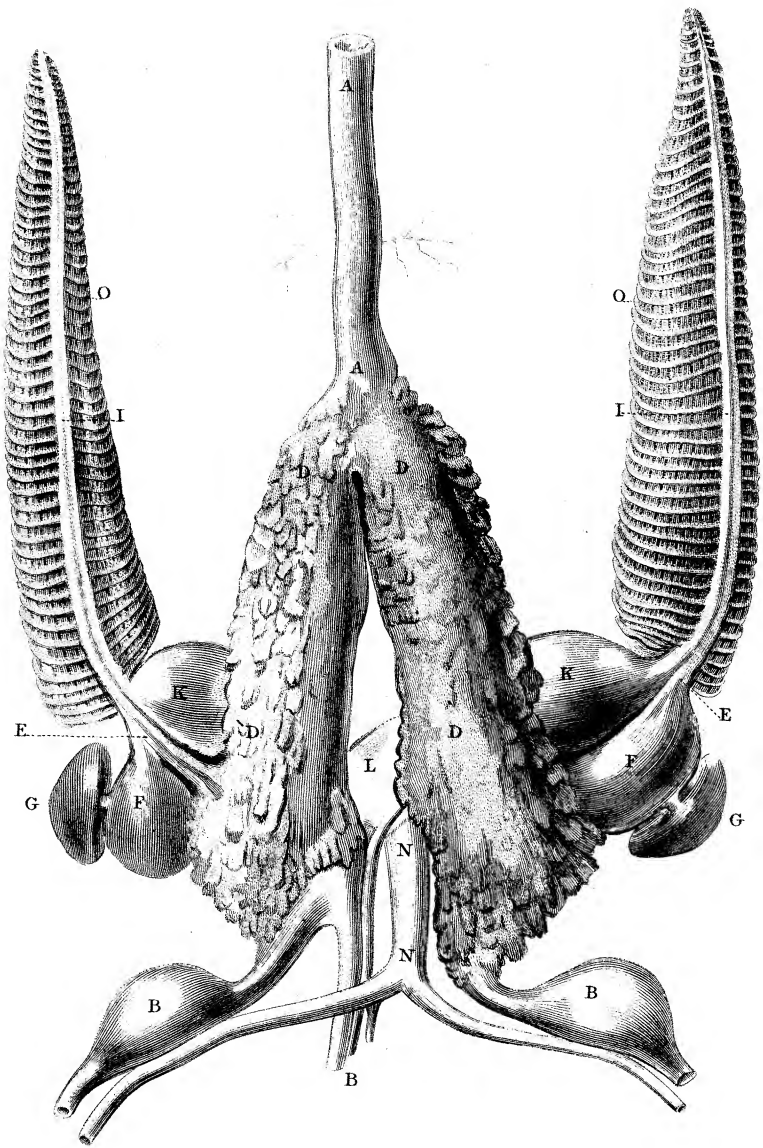
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Fig. 1.

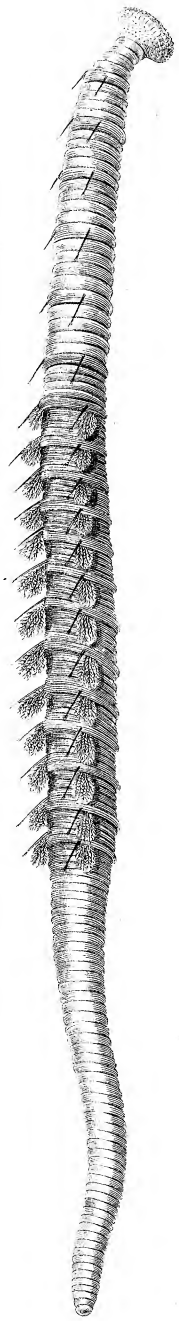

Fig. 2.

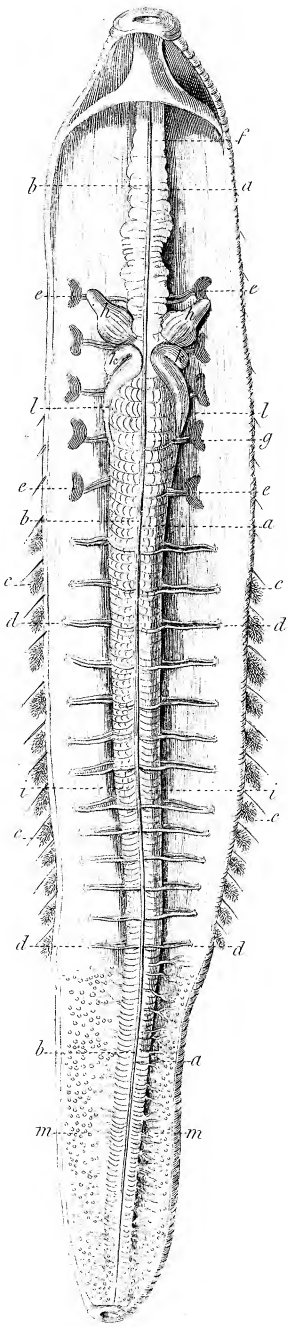

Fig. 3.

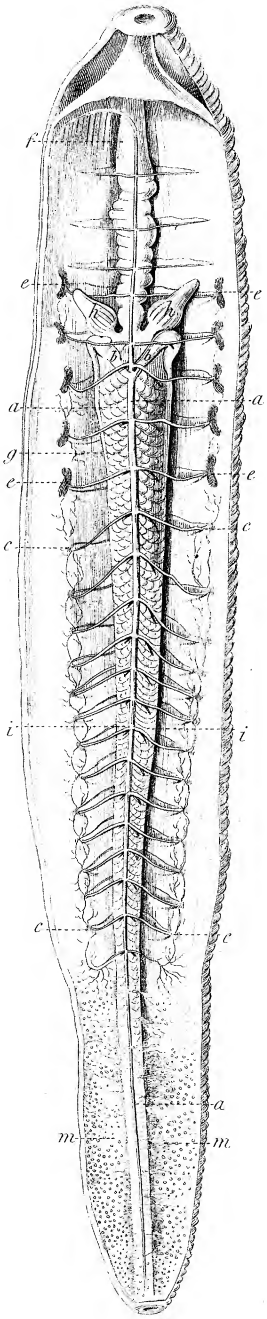

Fig. 4.